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Original Communication
Body composition unaltered for African women classified as 'normal but vulnerable' by body mass index and mid-upper-arm-circumference criteria

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Objective: To test the hypothesis that 'normal but vulnerable' adults, as defined by body mass index (BMI) in combination with mid-upper-arm-circumference (MUAC), are closer to normal than to malnourished ones. For that purpose body composition measurements were compared between normal and low BMI categories and according to MUAC value in an African context and for different age groups.
Design: Reanalysis of data from a previous cross-sectional cluster sample nutrition survey.
Setting: A rural area of the Republic of Congo, Central Africa.
Subjects: A representative sample ($n = 544$) of non-pregnant women.
Main outcome measures: Arm muscle area was calculated from measurements of triceps skinfold thickness and MUAC. Peripheral body fat was assessed by the sum of four skinfold thicknesses. The ratio of resistance at high and low frequencies was derived from whole body measurement of multifrequency bioelectrical impedance analysis and used as the extracellular to total body water ratio index.
Results: The prevalence of thinness decreased from 18.7% as defined by BMI alone to 9.0% as defined by BMI and MUAC. This difference was due to the group of subjects classified as 'normal but vulnerable' (9.7%). Prevalence of thinness increased with age when assessed by BMI alone, but no longer when assessed by BMI and MUAC. Comparison with the BMI $\geq 18.5\,kg/m^2$ category showed that in 'normal but vulnerable' subjects lower BMI was accompanied by lower both fat and lean compartments, in absolute values, but the equilibrium of body water compartments was not altered. In BMI < 18.5 women, low MUAC was associated with altered lean tissues, at peripheral and whole body level, whereas fat tissue did not differ.
Conclusions: 'Normal but vulnerable' subjects appeared as 'thin but healthy' rather than malnourished, at all ages, even though their BMI was lower than $18.5\,kg/m^2$. The new classification of thinness based on BMI and MUAC provides a more specific index of nutritional status when restricting the thin category to more at-risk subjects.
Descriptors: thinness; skinfold thickness; body fat and lean compartment; bioelectrical impedance analysis
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Introduction

The body mass index (BMI, weight/height^2 in kg/m^2) is a simple but adequate anthropometric index of adult nutritional status for use in populations. A BMI below 18.5 kg/m^2 has been suggested as a cut-off point for diagnosis of chronic energy deficiency (CED) (James *et al*, 1988; Ferro-Luzzi *et al*, 1992), now termed 'thinness' (WHO, 1995). However some uncertainty remains about the significance of mildly low values of BMI, initially referred as first grade of CED but which only reflects relative underweight for height. The combined measurement of BMI and physical activity, once taken as a further discriminating criterion for inadequacy of food intake, was later abandoned when it proved to be difficult to monitor (Ferro-Luzzi *et al*, 1992). James *et al* (1994) proposed therefore another but simpler refinement which takes into account limb tissue status as well as weight status and suggested a new classification of thinness based on BMI and mid-upper-arm circumference (MUAC), as shown in Table 1. They assumed that any energy imbalance would

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Table 1 Comparison of the two classifications proposed for grades I, II and III thinness in adults based on BMI alone or both BMI and MUAC

	BMI (kg/m²)			
	< 16	*16–16.9*	*17–18.49*	*≥ 18.5*
BMI alone	III	II	I	Normal
BMI and MUAC[a]				
MUAC ≥ cut-off point[b]	II	I	Normal but vulnerable	Normal
MUAC < cut-off point	III	II	I	? Normal

BMI = body mass index; MUAC = mid-upper-arm circumference.
[a]In developing countries conditions only.
[b]Cut-off point = mean MUAC 1 s.d.

lead to a preferential peripheral lean tissue wasting which would be more sensitively accounted for by MUAC than by BMI. By combining data from eight developing country communities they established an MUAC cut-off point corresponding to the mean minus one standard deviation. This choice was based on the analysis of the relationship between BMI and MUAC, with a MUAC of mean 1 s.d. corresponding to a BMI of approximatively 17. When compared to the classification based on BMI alone, subjects shift from the 'first grade' thinness category to normal when their MUAC value remains above this cut-off point. In this new scheme, subjects with a BMI of 17.0–18.49 and a MUAC above the cut-off point may be considered as 'normal but vulnerable', and no longer malnourished. It is likely that the use of this new category, which probably includes a large proportion of 'thin but healthy' subjects, enhances the diagnostic specificity for truly underweight adults. It aims at a precise demarcation, when there is a slight reduction in BMI, of those with more limited energy reserves but a preserved muscle mass, from those presumed to be malnourished because of having endured lean and fat body mass losses at the same time (James *et al*, 1994). However this rather theoretical classification, which clearly could lead to a rather large reduction in the prevalence of adults considered as energy deficient in most developing countries, has not been widely used yet, and its validity remains to be more firmly demonstrated.

Although more sensitive to peripheral tissue modifications than BMI, MUAC still does not differentiate between changes in fat-free and fat masses. In order to verify the assumption that 'normal but vulnerable' adults are closer to normal than to malnourished ones, we used data from a cross-sectional survey undertaken previously in a large representative sample of rural Congolese women (Gartner *et al*, 2000). Body composition was assessed by local measurements of skinfold thicknesses to document peripheral variations of fat (and, in combination with MUAC, of the lean compartment), and by whole-body multifrequency bioelectrical impedance analysis (BIA). The differentiation of the lean body mass into the body cell mass and the extracellular mass is very important in the nutritional assessment (Waterlow *et al*, 1992). As a matter of fact, the fluid balance is deranged in patients with malnutrition (Wahlqvist & Marks, 1990). The extra- to intra-cellular water ratio is increased, extra-cellular water volume being better preserved than cell mass (Forbes, 1988). We used the ratio of resistance at high and low frequencies as an index of a preserved (or altered) distribution of body water into the extracellular space (*Bioelectrical Impedance Analysis in Body Composition Measurement*, 2000). These body composition measurements were used to compare normal and low BMI categories and to check the appropriateness of the MUAC values proposed in combination by James *et al* (1994), in this African context, and particularly for different age groups.

Subjects and methods

Subjects

A cross-sectional nutritional survey took place in April 1992 (rainy season) in 30 villages in the Plateau Koukouya, a remote rural area of the Republic of Congo, Central Africa, where a representative sample of children < 5 y and their mothers was randomly selected by two-stage cluster sampling (Delpeuch *et al*, 1994). As the population used by James *et al* (1994) for their classification comprised subjects between 18 and 60 y of age, women outside that age range were not included in the analyses, as well as women having declared themselves pregnant, for whom BIA measurement was not performed; this resulted in a sample of 544 women. Informed consent of subjects was obtained before performing anthropometric and BIA measurements. Almost all of these women (91%) were basically agriculturists, actively engaged in crop field work.

Anthropometric measurements

Measurements were made by trained personnel using standard procedures (Lohman *et al*, 1988). The body weight of subjects (wearing light clothing and no shoes) was measured within 200 g with calibrated electronic scales (Téfal, France). Height was measured to the nearest millimeter with a portable gauge (Seca, Germany). The left MUAC was measured with the metric measuring tape at the midpoint of the upper arm with the subject's arm relaxed. Skinfold thickness measurements were done in a standard manner on the left side of the body using a Holtain (Crymych, UK) skinfold caliper. The measurements were made to the nearest mm at the triceps, biceps, subscapular and suprailiac sites in each woman by the same observer. Upper arm muscle area was calculated on the basis of measurements of the MUAC and triceps skinfold (TSF) using the standard formula as follows (Frisancho, 1990): arm muscle area $= (\text{MUAC}\quad (\text{TSF}\ \pi))^2/4\pi$. Arm muscle area was corrected for bone area by substracting 6.5 cm^2 from the calculated arm muscle area. Age was obtained by interview and verified with civil status documents or birth certificates whenever possible. As the use of the same cut-off point for thinness in different age groups is still questionable (WHO, 1995), three age groups were

established: 18–25, 26–40 and 41–60 y for comparison purposes.

Bioelectrical impedance analysis (BIA)
BIA was performed on the left side of the body with a body composition analyser (Model TVI-10, Danninger Medical, Columbus, OH, USA) with a four-electrode arrangement. The electrodes were paired, one pair acting as current electrodes, the other pair acting as detector electrodes. Electrodes were placed on the hand, wrist, foot and ankle of each subject according to the manufacturer's guidelines. Subjects were supine with their arms and their thighs apart. Measurements were performed each day between 8.30 am and 2.00 pm at a relatively constant outside temperature. The day of the survey, subjects were waiting for the measurer at home before going to work in the fields, so they had not had agricultural activity since the previous day. Under the field conditions, it was not possible to meet the other usual conditions for BIA measurements such as no eating or drinking within 4 h of the test, or recommendations about voiding the bladder beforehand. The calibration of the instrument was checked daily with standard resistors included in the analyser. All BIA measurements were performed by the same measurer.

The resistance (R) value of measurement at the frequency of 5 kHz (R_5) and 100 kHz (R_{100}) for each subject was read to the nearest 0.1 Ω from a digital display and recorded. Electrical theory indicates that length^2/resistance can be assumed to reflect conductor volume. In man, the value of height^2/resistance has been found to correlate highly with laboratory estimates of total body water (TBW) volume and fat-free mass (Lukaski *et al*, 1985; Segal *et al*, 1985; Kushner & Schoeller, 1986). At low frequencies the current cannot pass through the cell membrane (Ducrot *et al*, 1970) and R will be inversely related to the amount of extracellular water (ECW). At high frequencies the current can pass through the cell membranes and body R will be inversely related to the amount of TBW. The height$^2/R_5$ (ECW volume index) to height$^2/R_{100}$ (TBW volume index) ratio has been used as a simple index of ECW/TBW ratio. Abnormal values for this ratio are likely to be due to an altered distribution of body water between extracellular space and intracellular space (Segal *et al*, 1991; Segal, 1992; Tagliabue & Cena, 1996; *Bioelectrical Impedance Analysis in Body Composition Measurement*, 2000).

Statistical analysis
Statistical software used for data entry, validation and analysis was Epi-Info (Dean *et al*, 1994) and the SAS system, release 6.12 for Windows. For quantitative variables, values are expressed as means and standard deviations, and analysis of variance was used to compare age and thinness groups. The risk difference (difference of prevalences) was used to compare the two definitions of thinness across groups (Rothman & Greenland, 1998). To test whether the difference between the two methods varied according to age, a generalized linear model (identity link, binomial distribution) including a method×age interaction was used. GEE (generalized estimating equations) methodology, performed with Proc Genmod in SAS (SAS Institute, 1997), was used to take into account the within-subjects correlations (Chavance, 1999; Diggle *et al*, 1994). The type I error risk was set at 0.05 for all analyses.

Results

Table 2 shows the age and basic anthropometric characteristics of the $n = 544$ subjects. When compared to other African populations, women from our sample had similar mean age, weight, BMI and MUAC and slightly higher height and lower TSF than women from Malawi, for instance (Pelletier *et al*, 1991). Among the eight developing communities used by James *et al* (1994), five were from Africa. All of them had higher mean age when compared with our sample, those from Somalia and Ethiopia had lower BMI and MUAC value, and those from Zimbabwe, Mali and Senegal had slightly higher MUAC. Women from Mali and Senegal (James *et al*, 1994) had the same mean BMI value when compared to our sample. The cut-off point of mean MUAC-1 s.d. was 23.0 cm in our sample. Table 3 gives the distribution of the subjects according to the cut-off points of BMI alone (Ferro-Luzzi *et al*, 1992) or of BMI and MUAC (James *et al*, 1994). There was a medium to high prevalence of low BMIs (18.7%) according to WHO

Table 2 Characteristics of the $n = 544$ rural Congolese women (mean (s.d.) [range])

	Age (y)	*Height (cm)*	*Weight (kg)*	*BMI (kg/m^2)*	*MUAC (cm)*
Total sample ($n = 544$)	29.5 (8.2)	158.1 (5.7)	51.4 (6.9)	20.5 (2.5)	25.1 (2.1)
	[18–56]	[141.1–175.2]	[35.8–81.2]	[15.2–33.8]	[19.0–34.5]
Age 18–25 y ($n = 221$)	21.7 (2.1)	158.0 (5.3)	51.7 (6.1)	20.7 (2.1)	24.7 (1.7)
	[18–25]	[145.2–173.3]	[36.0–72.0]	[15.2–28.8]	[19.0–31.4]
Age 26–40 y ($n = 261$)	32.5 (4.5)	158.0 (6.1)	51.1 (7.4)	20.5 (2.7)	25.3 (2.4)
	[26–40]	[141.1–175.2]	[36.0–80.8]	[15.9–33.8]	[20.0–34.4]
Age 41–60 y ($n = 62$)	45.6 (3.3)	159.1 (5.8)	51.6 (7.7)	20.3 (2.7)	25.6 (2.0)
	[41–56]	[145.1–171.2]	[35.8–81.2]	[16.2–32.5]	[21.5–30.2]

BMI = body mass index; MUAC = mid-upper-arm circumference.

Table 3 Distribution of the $n = 544$ women according to BMI and MUAC cut-off points

	BMI (kg/m^2)			
	< 16	16–16.9	17–18.49	≥ 18.5
BMI alone	4 (0.7)[a]	16 (2.9)	82 (15.1)	442 (81.3)
BMI and MUAC:				
MUAC ≥ 23.0 cm	1 (0.2)	5 (0.9)	53 (9.7)	420 (77.2)
MUAC < 23.0 cm	3 (0.6)	11 (2.0)	29 (5.3)	22 (4.0)
Percentage MUAC < 23.0 cm	75.0%	68.8%	35.4%	5.0%

BMI = body mass index; MUAC = mid-upper-arm circumference.
[a] *n* (%).

criteria (WHO, 1995). Almost all subjects with a BMI ≥ 18.5 had a satisfactory MUAC value (95.0%). In those with BMI < 18.5, 42.2% had a MUAC below the cut-off point of 23.0 cm. Our result was similar to that of the international sample of James *et al* (1994) in which 38.6% of women with a BMI < 18.5 had a MUAC below the mean 1 s.d. The prevalence of thinness therefore decreased from 18.7% as defined by BMI alone to 9.0% as defined by BMI and MUAC (Table 3). This difference was due to the group of subjects classified as 'normal but vulnerable' (9.7%), who were still not 'normal', but no longer 'thin', in the new classification. The proportion of 'normal but vulnerable' subjects among those presenting a BMI of 17.0–18.49 kg/m^2 was 64.6% in our sample whereas it was 78.9% in the overall sample studied by James *et al* (1994).

The prevalence of thinness with age was different according to methods of assessment: the method×age interaction *P*-value was 0.008 (Table 4). There was an increase with age ($P = 0.0046$) when assessed by BMI alone, but no longer ($P = 0.25$) when assessed by BMI and MUAC. In fact, the increase when using BMI alone was largely due to women with a MUAC ≥ 23.0 cm, that is women graded as 'normal but vulnerable' in the new classification.

Table 4 Percentage distribution of thinness assessed either by BMI alone or by both BMI and MUAC, by age categories

			Other	
	Criteria	Thin	Normal but vulnerable	Normal
Total sample ($n = 544$)	BMI alone	18.7%	—	81.3%
	BMI + MUAC	9.0%	9.7%	81.3%
Age 18–25 y ($n = 221$)	BMI alone	12.3%	—	87.8%
	BMI + MUAC	6.8%	5.4%	87.8%
Age 26–40 y ($n = 261$)	BMI alone	22.6%	—	77.4%
	BMI + MUAC	11.1%	11.5%	77.4%
Age 41–60 y ($n = 62$)	BMI alone	25.8%	—	74.2%
	BMI + MUAC	8.1%	17.7%	74.2%
P-value[a]		0.0080		

BMI = body mass index; MUAC = mid-upper-arm circumference.
[a] Null hypothesis of no interaction method×age (thin *vs* other).

Analysis of variance revealed significant global differences between the different categories of nutritional status (according to the classification based on both BMI and MUAC) for all the response variables related to body composition (Table 5).

Firstly, comparison between 'normal' subjects (BMI ≥ 18.5) and 'normal but vulnerable' ones, showed that, in this new intermediate category, lower BMI was accompanied both by lower fat and lean compartments, in absolute values, as shown by lower triceps or four skinfold thicknesses and arm muscle area. Nevertheless equilibrium of body water compartments was not altered, as shown by similar values of the ECW/TBW ratio index in the two groups.

Secondly, in the BMI 17.0–18.49 category, we compared the body composition of 'normal but vulnerable'

Table 5 Body composition (mean s.d.) of rural Congolese women by nutrition status categories according to the combined BMI and MUAC classification (James *et al*, 1994)

	n	Nutrition status	Triceps skinfold thickness (mm)	Sum of four skinfold[a] thicknesses (mm)	Arm muscle area[b] (cm^2)	ECW/TBW ratio index
BMI ≥ 18.5	442	Normal	12.4 (4.0)[c]	34.3 (11.1)[c]	31.0 (5.4)[c]	0.829 (0.0183)
17.0 ≤ BMI < 18.5						
MUAC ≥ 23.0 cm	53	Normal but vulnerable	9.2 (2.6)	24.4 (4.2)	29.4 (3.8)	0.826 (0.0210)
MUAC < 23.0 cm	29	Thin (I)	8.4 (2.3)	23.4 (5.2)	23.8 (2.8)[d]	0.841 (0.0221)[d]
BMI < 17.0						
MUAC ≥ 23.0 cm	6	Thin (I, II)	7.6 (1.6)	20.6 (2.6)	31.5 (6.9)	0.831 (0.0084)
MUAC < 23.0 cm	14	Thin (II, III)	8.4 (2.9)	22.8 (4.7)	22.0 (3.9)[e]	0.853 (0.0164)[e]
F (P-value)			*20.3 ($<10^{\ 6}$)*	*22.9 ($<10^{\ 6}$)*	*23.4 ($<10^{\ 6}$)*	8.9 ($6.10^{\ 7}$)

BMI = body mass index; MUAC = mid-upper-arm circumference; ECW = extra cellular water; TBW = total body water.
[a] Tricipital, bicipital, subscapular and suprailiac.
[b] Corrected for bone.
[c] Significant difference between normal and normal but vulnerable groups.
[d] Significant difference between MUAC categories within the 17.0 ≤ BMI < 18.5 group.
[e] Significant difference between MUAC categories within the BMI < 17.0 group.

Table 6 Body composition (mean (s.d.)) of the 'Normal by vulnerable' women ($17 \leq$ BMI $< 18.5\,kg/m^2$ and MUAC ≥ 23.0 cm) by age categories

Age category	*Triceps skinfold thickness (mm)*	*Sum of four skinfold[a] thicknesses (mm)*	*Arm muscle area (cm^2)[b]*	*ECW/TBW ratio index*
Age 18–25 y (*n* = 12)	9.3 (2.7)	25.7 (4.5)	28.4 (3.3)	0.833 (0.0169)
Age 26–40 y (*n* = 30)	9.4 (2.6)	24.1 (4.1)	29.6 (4.5)	0.832 (0.0153)
Age 41–60 y (*n* = 11)	8.5 (2.5)	23.7 (4.3)	29.9 (1.9)	0.820 (0.0351)
F (P-value)[c]	*0.46 (0.63)*	*0.76 (0.48)*	*0.47 (0.63)*	*1.28 (0.29)*

BMI = body mass index; MUAC = mid-upper-arm circumference; ECW = extra cellular water; TBW = total body water.
[a]Tricipital, bicipital, subscapular and suprailiac.
[b]Corrected for bone.
[c]Comparison among the three age groups.

women with those having a MUAC < 23.0 cm. The mean of the triceps skinfold thickness value was similar in the two groups, as in the multiple sites approach, where body fat did not differ between MUAC groups as reflected by the sum of four skinfold thicknesses. There was therefore no difference in peripheral body fat within this 17.0–18.49 BMI range, whatever the category of MUAC value. On the other hand, the arm muscle area was significantly lower in low MUAC when compared to normal MUAC women. The lower MUAC was then explained by a specific loss of arm fat-free mass. And the higher ECW/TBW ratio index in the low MUAC group reflected an alteration of the body water compartments equilibrium, suggesting an alteration of the lean compartment at the whole-body level.

Finally, the difference in MUAC within the BMI < 17.0 group was again apparently due to lower arm muscle mass but with no significant difference in fat mass. At the whole-body level, water distribution appeared also clearly different between the two MUAC groups.

As the prevalence of 'normal but vulnerable' women increased drastically after the age of 25 y, we compared the body composition of these women in the three age categories. As shown in Table 6, aspects of body composition did not differ between groups.

Discussion

In our sample, almost all women with a BMI above $18.5\,kg/m^2$ had, as expected, a MUAC above 23.0 cm and should reasonably be considered as normal. Among those having a BMI in the $17.0-18.49\,kg/m^2$ range, 64.6% also had a MUAC above the calculated 23.0 cm cut-off point; they therefore entered the proposed new category of 'normal but vulnerable' women. As expected, these subjects had lower body compartments (both lean and fat mass indices) when compared to 'normal' group, because of lower BMI, but the distribution of body water compartments appeared to be preserved. Among women with BMI < 18.5, low MUAC was associated with altered lean tissues, at peripheral and whole body level, whereas fat tissue did not differ. We had previously shown in our sample that a low BMI was not a good predictor of changes in body composition (Gartner *et al*, 2000). The addition of MUAC in combination seems to offer a much better appreciation of these changes.

According to internationally suggested criteria (WHO, 1995), the prevalence of low BMI in the population studied was rather high, and this certainly reflects a disadvantaged situation of women in this region. Our study confirms, however, that the prevalence of underweight in this population of African rural women, as assessed by measurement of BMI and MUAC, was far less than the one obtained by BMI measurement alone (9.0% *vs* 18.7%). Underweight in adults is a common answer to energy deprivation, where adipose and lean tissues are then used for fuel. Ferro-Luzzi *et al* (1994) have shown, in conditions of seasonal energy stress, that the degree of lean body mass depletion will depend on the quantity of adipose tissue stored. A small fat mass decrease may have no immediate consequences, in contrast to lean body mass depletion, generally peripheral muscle, which may limit physical capacity for active life. James *et al* (1994) proposed their new classification based on MUAC, along with BMI, to assess the relative degree of depletion of both fat and lean peripheral tissues and detect people truly at risk. We can conclude from our study that, despite a slightly lower BMI, 'normal but vulnerable' women kept a normal equilibrium between body compartments contrarily to thin women, and therefore it seems to be justified to differentiate these two categories.

In rural Congolese women, the prevalence of underweight, according to BMI, increased with age (Delpeuch *et al*, 1994). This raises two questions. The first is the appropriateness of the BMI cut-off for young women, who may have not completely matured yet or who may normally be fitter. The second one is the significance of such changes in older women in terms of undernutrition. According to our results, the prevalence of thinness, estimated by a low BMI associated with a low MUAC, did not change with age. The difference rested essentially on the 'normal but vulnerable' grade. Are these women identical in all age categories? Our results show no difference in body composition between categories. We can therefore conclude that this apparent increase in prevalence of underweight women was in fact due to a slight but equilibrated decrease of body compartments which, if far from an ideal situation,

at least should not limit their current activity nor endanger their health situation. It is reasonable to estimate that 'true' undernutrition, ie as assessed by combined BMI and MUAC, does not change specifically with age. This may change our appreciation of risk factors in these populations and studies should be made to further document this. There seems also to be no reason not to apply the same cut-off point for young women.

It has been previously shown in African women as in others that physical activity for active life is better when BMI is above 18.5 kg/m^2 (ie the 'normal' group), while a BMI below 17.0 kg/m^2 (ie clearly underweight) increases the frequency of illness (Shetty & James, 1994). However, the case is not so clear for women lying in the range between these two BMI cut-off points. Our results reinforce the idea that the new category of 'normal but vulnerable' subjects appeared as 'thin but healthy' rather than undernourished at all ages, even though their BMI was lower than 18.5 kg/m^2, which undoubtedly, reflects a long-term energy deficit.

The new classification of thinness based on BMI and MUAC proposed by James *et al* (1994), although not directly measuring fat and lean body mass changes, seems to provide a more specific index of nutritional status when restricting the thin category to more at-risk subjects (ie those presenting altered fat-free compartment even with a modest reduction in BMI). It remains to be seen if the same conclusions hold for various populations, as the average level of fatness for a given BMI differs between populations (Norgan, 1990). It also remains to relate this finding to precise functional modifications (eg pregnancy outcome or lactation performance) and to test further how this classification will be sensitive to changes in the context of interventions.

Finally, one could question the validity of our observations if a different cut-off was to be chosen for MUAC: as a matter of fact, James *et al* (1994) mentioned an average value of 22.0 cm (mean 1 s.d.) for their pooled sample of women from different countries around the world. If such a value was to be chosen as a reference cut-off point, eg for the purpose of an international standardisation, like for BMI, would the body composition of 'normal but vulnerable' women still be comparable to that of 'normal' ones? Such a move of the MUAC cut-off value gives rather different proportions for our sample of 'normal but vulnerable' and 'thin' women in the combined classification (respectively 13.4% and 5.4%). However, in that case also, significant disturbances of body water compartments are confined to the low MUAC categories only (ECW/TBW ratio index was 0.830 (s.d. 0.0214) for the 'normal but vulnerable' category, $P = 0.73$ when compared to the 'normal' category; it was 0.847 (s.d. 0.0259) for the MUAC < 22 cm group within $17 \leq \text{BMI} < 18.5$ women (thin I in Table 5), $P = 0.027$, when compared to 'normal but vulnerable' women). Therefore, the adoption of a cut-off point within a given range of sensitivity/specificity, which however remains to be more firmly defined, should not invalidate this observation.

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